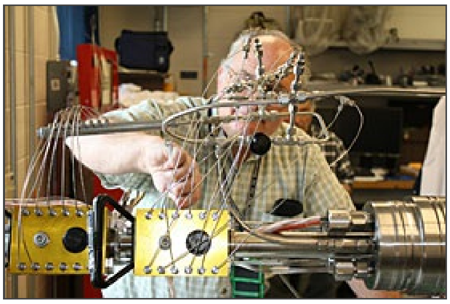
Claren Woolstenhulme, Blaine Grover, Scott Barrie, Steve McClaskey, and S. Eric Egan of the Advanced Graphite Capsule project team pose near the top end of the capsule.

INL team helps pave way to Generation IV reactor

by Brett Stone, *Nuclear Science & Technology communications intern*

Cleaner. Safer. Cheaper. More. Thanks to the work of a team at Idaho National Laboratory, the promised deliverables of fourth generation nuclear power plant graphite technology are one step closer.



Steve McClaskey checks the pneumatic tubing that will regulate the rams in the capsule.

Fourth generation nuclear reactors, the nuclear power plants of tomorrow, will provide safer, less expensive and more environmentally friendly energy. A critical step in developing new Very High Temperature Reactors (VHTR) is certifying the graphite that is used in many parts of the reactor's core. In recent years, it has become necessary to develop new nuclear-grade graphite and certify it for use in the next generation of gas-cooled nuclear reactors.

Today, nuclear experts envision two different versions of gas cooled VHTRs for next-generation use. Both designs will require large amounts of high-quality graphite.

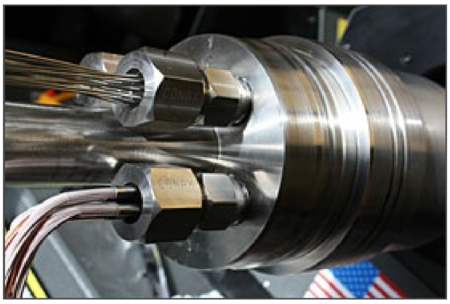
The "pebble-bed" style reactor uses billiard-ball-size "pebbles" of nuclear fuel particles coated with several layers of silicon-carbide and carbon. The pebbles enter the reactor from the top, work their way down through and exit the reactor from the bottom. There, they are monitored for remaining fuel to make another pass. Or, if the useable fuel is consumed by the time it reaches the bottom, it is collected for disposal. A second design utilizes a honeycomb block of graphite into which fuel rods would be inserted.

Assembling the inside of the capsule with its various rams, wires and sensors.

In recent years, the supplies of nuclear-grade graphite have been exhausted and researchers have had to turn to new sources. Different sources of graphite tend to be very idiosyncratic, each one having very specific characteristics that set it apart from others. Graphite must be tested so the American Society for Testing and Materials and the American Society of Mechanical Engineers can certify it for use in the design and construction of reactors.

Information on the amount a given piece of graphite will expand when exposed to heat, or shrink when irradiated, is vital to enable safe reactor design. Now that new reactors will have to use sources of graphite whose characteristics haven't been verified, it's important to perform tests to gain that information.

Enter INL and its team of engineers, led by Technical Director David Petti, Graphite Principal Investigator William Windes, and Design and Irradiation Technical Lead Blaine Grover. They, along with a team of around 20 other employees and the support of over 50 other specialists, took on the challenge of designing and building the experiment to validate these new graphite sources.



Pneumatic tubes and sensor wires separate at back end of capsule.

The result, after three years of planning, machining, wiring and welding, is the Advanced Graphite Capsule project. This six-phase project will test over 2,000 different samples of graphite in INL's Advanced Test Reactor facility over a roughly 10-year period that will last until 2020.

The idea for the project came from early tests run in the 1960s at Oak Ridge National Laboratory. The current experiment improves on early designs. Besides being larger than previous experiments, the new design also makes it easier for experimenters to closely monitor and control the temperature, pressure and irradiation levels of the samples without removing them from the reactor or halting the experiment.

By using pneumatic rams to adjust the pressure on the graphite samples, experimenters will avoid the warping and even possible failure of the pressure adjusting mechanisms that troubled early experimenters.

End of capsule protrudes from automatic welder near end of assembly process.

None of this could have been accomplished without a world-class design and fabrication team. The finished test capsule, with its shiny stainless steel shell and protruding wires and cables off the back end, almost looks more like something from a hot-rod spaceship than a highly sophisticated piece of experimental equipment.

And some of the processes used to assemble the capsule really do seem to have been taken out of a Star Trek shuttle bay. Take the welding, for example. On the 14-foot section of the capsule that will be entered into the reactor core, 13 super precise welds cause less than twenty-thousandths of an inch in variation from one end of the capsule to the other.

Yet the automated welding machine that performed this stellar work is not from a galaxy "far, far away," but is built by a company located just a short drive from INL. Although AMET started up in the basement of co-owner Dave Stompro, the Rexburg, Idaho, company builds automated welding machines that have been used to help manufacture everything from NASA space shuttle tanks to the titanium frames for B1-B bombers.

"We're certainly glad that our equipment is getting to be utilized for that level of work," Don Schwemmer, AMET co-founder and president, said of the INL project. "On the other hand, it's not just our equipment. They've got the expertise to use the equipment we provide."

Marv Harker Operates the AMET automatic welder as it joins two sections of the capsule.

The rest of the project testifies to the expertise of the Advanced Graphite Capsule team. A beehive of cables, sensors, tiny pneumatic tubing and rams are strategically woven and nested to fit inside with the intricately cut ceramic insulator and sample carrier.

With the capsule finished and inspected, it will enter INL's Advanced Test Reactor in June. There, it will endure average temperatures of 600 degrees Celsius (six times the temperature of boiling water) for almost two years. Five similar Advanced Graphite Capsule experiments will follow the first one.

The capsules will be exposed to successively increased temperatures so the last capsule will experience temperatures of over 1,200 degrees Celsius. Experimenters will also expose the samples to varying levels of radiation, all several times what they would experience in a normal reactor. The higher radiation levels give researchers a sense of how the material will behave under the prolonged irradiation the graphite would experience over many years in a next-generation reactor.

After data from each test is gathered and each capsule is removed from the reactor, more work awaits the team. Post Irradiation Examination will involve removing the graphite samples and measuring and recording the differences in each one's characteristics compared to before its trip to the reactor.

Every detail of the half-inch diameter samples will be considered. Researchers will construct a new database after measuring how the irradiation changed the physical dimensions of the pieces, examining their "thermal diffusivity" using lasers, and recording other specifications.

This information will allow those who build advanced nuclear reactors to be sure that communities will, for generations, reap the benefits of clean, safe, inexpensive and abundant energy to power their progress.

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